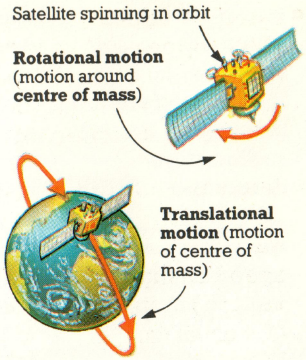
Motion

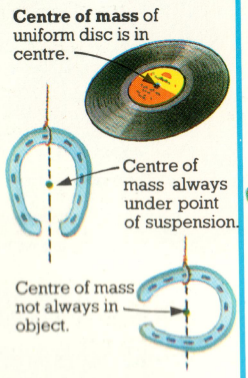
Motion is the change in position and orientation of an object. The motion of a **rigid** object (one which does not change shape) is made up of **translational motion**, or **translation**, i.e. movement of the **centre of mass** from one place to another and **rotational motion**, or **rotation**, i.e. movement around its centre of mass. The study of the motion of points is called **kinematics**.



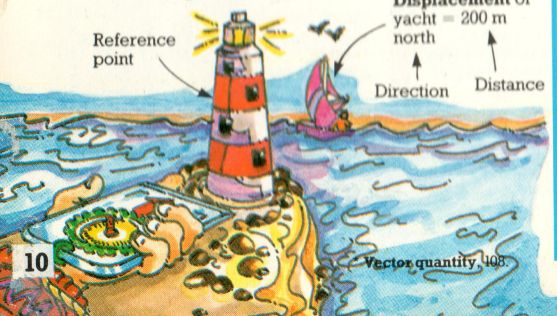
Linear motion

Linear or **rectilinear motion** is movement in a straight line and is the simplest form of **translational motion** (see introduction). The linear motion of any rigid object is described as the motion of its **centre of mass**.

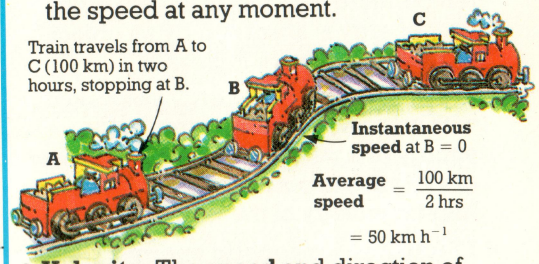
- **Centre of mass**. The point which acts as though the total mass of the object were at that point. The centre of mass of a **rigid** object (see introduction) is in the same position as its **centre of gravity** (the point through which the earth's gravitational force acts on the object).



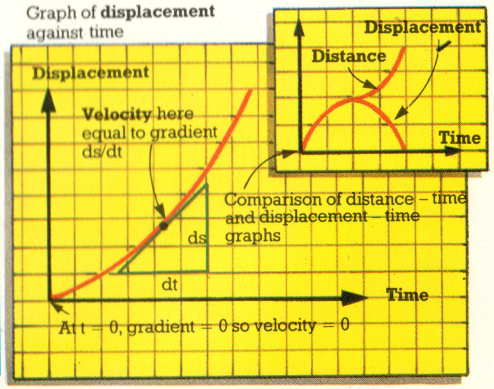
- **Displacement**. The distance and direction of an object from a fixed reference point. It is a **vector quantity***. The position of an object can be expressed by its displacement from a specified point.



- **Speed**. The distance an object travels in a certain length of time. If the speed of an object is constant, it is said to be moving with **uniform speed**. The **average speed** of an object over a time interval is the distance travelled by the object divided by the time interval. The **instantaneous speed** is the speed at any moment.

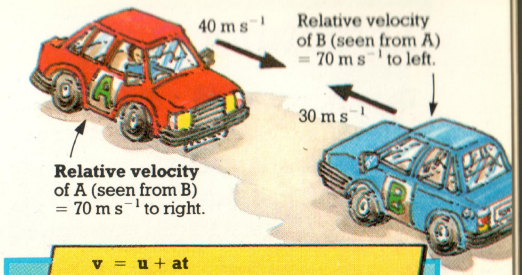


- **Velocity**. The **speed** and direction of an object (i.e. its **displacement** in a given time). It is a **vector quantity***. **Uniform velocity**, **average velocity** and **instantaneous velocity** are all defined in a similar way to **uniform speed** etc. (see speed).



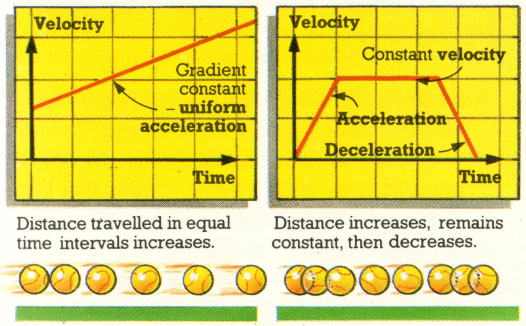
* Vector quantity, 108.

- **Relative velocity**. The **velocity** which an object appears to have when seen by an observer who may be moving. This is known as the velocity of the object relative to the observer.



- **Acceleration**. The change of **velocity** of an object in a certain time. It is a **vector quantity***. An object accelerates if its **speed** changes (the usual case in **linear motion**) or its direction of travel changes (the usual case in **circular motion***). **Deceleration** in one direction is acceleration in the opposite direction to the motion (negative acceleration). An object whose velocity is changing the same amount in equal amounts of time is moving with **uniform acceleration**.

Graphs of **velocity** against time

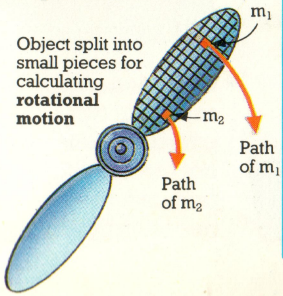


Distance travelled in equal time intervals increases.

Distance increases, remains constant, then decreases.

Rotational motion

Rotational motion is the movement of an object about its **centre of mass**. In rotational motion, each part of the object moves along a different path, so that the object cannot be considered as a whole in calculations. It must be split into small pieces and the **circular motion*** of each piece must be considered separately. From this, the overall motion of the object can be seen.

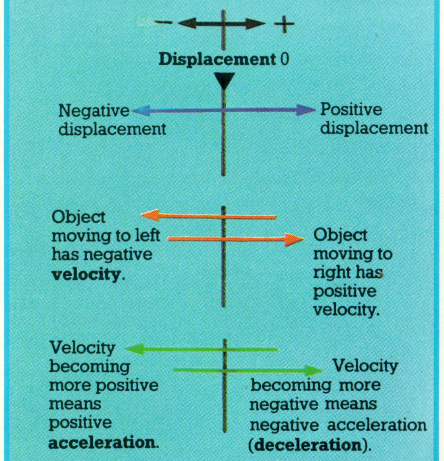


* Circular motion, 17; Vector quantity, 108.

$$v = u + at$$
$$s = \tfrac{1}{2}(u + v)t$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

where t = time; u = initial **velocity** at time = 0; v = final velocity after t; s = **displacement** after t; a = **acceleration** (constant).

- **Equations of uniformly accelerated motion**. Equations which are used in calculations involving **linear motion** with **uniform acceleration**. A **sign convention** must be used. The equations use **displacement**, not distance, so changes of direction must be considered.



- **Sign convention**. A method used to distinguish between motion in opposite directions. One direction is chosen as positive, and the other is then negative. The sign convention must be used when using the equations of motion (see above).